

MEMORANDUM FOR: Clifton S. Middleton
Project Director, Survey Section B

FROM: Charles W. Challstrom
Director, National Geodetic Survey

SUBJECT: INSTRUCTIONS: VIRGINIA FBN, 2000 (GPS-1188)
WEST VIRGINIA FBN, 2000 (GPS-
1462)

Task Numbers: 8K6D2000 (FBN)
8K6D4000 (CORS FBN/CBN TIE)

GENERAL:

The National Geodetic Survey (NGS), in accordance with the NGS Strategic Plan, is engaging in a campaign of observing stations of the Federal Base Network (FBN) to complete the ellipsoidal and orthometric height components of the FBN. This survey will observe the 29 FBN stations in Virginia and West Virginia.

In Virginia, there are 19 FBN stations. FBN station J 335 has been found destroyed. It has been replaced by station BRIDGE (PID FY1377). In West Virginia, there are 10 FBN stations, and all have been recovered as suitable for GPS occupation.

Also in Virginia, station CAPE USCG (PID AB3999) has been selected over station HENRY USCG at one location, and station ZDC B (PID AA3618) has been selected over station ZDC A at another location.

In West Virginia, stations Z 204 (PID HX1904), K 234 (PID HX1057), and F 186 (PID HX2244) have been included to serve as bench mark ties only. In Virginia, no additional bench marks were needed.

In addition, at each of four Continuously Operating Reference Station (CORS) sites in Virginia, a pair of CORS reference marks is to be tied to both the local FBN/CBN and the CORS antenna.

The four CORS are: Blacksburg, Driver, Gloucester Point, and Wachapreague. Details for each are given under SPECIFICATIONS.

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Also, stations V 13 (PID GV1207) and MUTT (PID GW0186) in Virginia have been added to the project in order to check ellipsoid heights versus leveling. The stations are to be observed to FBN specifications.

Lastly, a station at each of nine tide sites in Virginia is included in the project and is to be surveyed to FBN specifications. The nine tide sites are: Wachapreague, Kiptopeke, Colonial Beach, Lewissetta, Windmill Point, Gloucester Point, Sewells Point, Chesapeake Bay Bridge Tunnel, and Money Point.

A full-wavelength, dual-frequency Global Positioning System (GPS) receiver is needed to act as Central Temporary CORS (CTCORS) throughout the project. The receiver shall be deployed at relatively secure stations within the vicinity of the ongoing observing sessions. The receiver shall continuously collect data at a 30-second epoch collection interval for a minimum of 72 hours and for as long as observations are ongoing in the vicinity of the CTCORS.

In Virginia, as many as 120-130 Cooperative Base Network (CBN) stations may be co-observed. The coordinator is Mr. Mike Zmuda, Virginia Department of Transportation. In West Virginia, as many as 40 CBNs may be co-observed. The coordinator there is Mr. Dave Sypolt, West Virginia Association of Land Surveyors. The project will be performed under the technical management of NGS.

PURPOSE:

In order to meet America's accelerating positioning and navigation needs, the existing coordinate reference system must be continually enhanced to provide the accessibility and high accuracy required for use with GPS. The digital revolution in mapping, charting, and surveying requires a National Spatial Reference System (NSRS) consisting of, among

other components, a network of monumented points having four-dimensional positions. The FBN fulfills the requirements for this component. NGS is charged with the Federal responsibility for establishment, observation, monitoring, and maintenance of the FBN. The FBN provides the critical network foundation for an accurate, consistent, reliable NSRS.

The NSRS, in turn, provides the common geographic framework for America's spatial data infrastructure. As such, the NSRS serves as the basis for mapping, charting, navigation, boundary determination, property delineation, infrastructure development, resource evaluation surveys, and scientific applications, including crustal motion monitoring, modeling of flooding, storm surge, pollution trajectories, and agricultural runoff. A modernized, accurate, consistent, reliable NSRS is of enormous benefit to state, county, tribal, local, and Federal authorities, as well as to the private sector.

The reference marks established at each of the four CORS sites will provide a very accurate tie to the antenna as an aid to reposition the antenna should that become necessary. The FBN/CBN tie to the reference marks will also provide site station coordinates relative to the local FBN/CBN, thus reducing the potential for relative error between the reference marks and the local network. It will also provide a check on the FBN/CBN, relative to the CORS coordinates.

SPECIFICATIONS:

Project requirements for the FBN observations are to ensure 2-centimeter local accuracy in the horizontal component, as well as 2-centimeter local accuracy for the ellipsoid heights.

Data from the CORS in the region are to be used in the processing. There are twelve NGS CORS in the area to be selected from. Five are in Virginia; three are in Maryland; two are in North Carolina; and one each is in Pennsylvania and Ohio.

The five NGS CORS in Virginia are: Blacksburg (BLKV), Richmond (RIC1), Gloucester Point (GLPT), Driver (DRV1), and Wachapreague

(VIMS). The three CORS in Maryland are: Gaithersburg (GAIT), Greenbelt (GODE), and Solomons Point (SOL1). The two CORS in North Carolina are: Duck (DUCK) and Asheville (ASHV). The CORS in Pennsylvania is Pittsburgh (PIT1). The CORS in Ohio is Galbraith (GALB). Positions and data for the NGS CORS are available from the NGS web site.

General specifications for the project are as follows. At each FBN site, three sessions of 5 1/2 hours duration for each session shall be observed. The observing scheme shall be arranged so that for each station, the start time of one of the observing sessions shall be at least 4 hours different from the other two. The observing scheme shall be arranged to ensure that adjacent FBN stations are directly connected in at least one observing session, and at least half of all base lines are repeated.

Specific to the four CORS sites is that for the two reference marks at each site, two sessions of 2 hours each shall be observed. In order to provide a check, the equipment shall be broken down and reset with a minimum of 30 minutes between the two sessions. Since the CORS site is to be tied to the nearest FBN/CBN station, the FBN/CBN station must be occupied simultaneously with the two reference marks. If the FBN/CBN tie station is part of the scheduled FBN or CBN to be occupied and is being occupied during a normal FBN/CBN session, occupy the station for the entire 5 1/2 session with no equipment breakdown.

If the FBN/CBN station is a CBN that is not scheduled to be occupied as part of the project, do observe the two 2-hour sessions and break down the equipment as described above.

Specifics for each of the CORS sites are as follows:

- (1) At the Blacksburg CORS, the reference marks are BCB A (PID AI2793) and VA TECH CBL 150 (PID AI2794). The FBN/CBN tie station is BLACKS (PID GX0342), a scheduled CBN. The backup tie station is VA 13 (PID GX3487), also a scheduled CBN.

(2) At the Gloucester Point CORS, the reference marks are 0360047 (no PID) and 863 7624 GAUGE (no PID). The FBN/CBN tie station is GLOPORT (PID GV5884), a scheduled CBN. The backup tie station is VETERAN (PID GV0189), also a scheduled CBN.

(3) At the Wachapreague CORS, the reference marks are 863 1044 K (no PID) and 863 1044 J (no PID). 863 1044 J is also one of the additional nine tidal marks. Because 863 1044 J will be occupied to FBN specifications (as one of the tidal marks), one of the three 5 1/2 hour sessions can be used in lieu of the two 2-hour sessions (i.e., observe the station for the entire 5 1/2 FBN session with no equipment breakdown; for reference mark 863 1044 K, do observe the two 2-hour sessions and break down the equipment). The FBN/CBN tie station is VCR 1 (PID FW2005), a scheduled CBN. If VCR 1 is not suitable to be occupied, contact Doug Hendrickson, NGS (listed under LIAISON), for a backup station.

(4) At the Driver CORS, new reference marks must be established (due to a change in specifications requiring that CORS reference marks be within 1 km of the CORS antenna). Names and descriptions for the reference marks will be provided.

The FBN/CBN tie station is 2850 (PID FX5373), a scheduled CBN. The backup tie station is 2795 (PID FX5372), also a scheduled CBN.

In general, station occupation and observing procedures must be carried out according to appropriate sections of the "NGS Operations Handbook" and the current applicable receiver field manuals. Data formats and digital file definitions are given in "Input Formats and Specifications of the National Geodetic Survey Data Base," Volume I. Horizontal Control Data, Federal Geodetic Control Subcommittee, September 1994, revised and reprinted November 1998. Success in meeting the accuracy standards will

be based on repeatability of measurements and adjustment residuals.

General specifications for the project are given in "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques," Version 5.0: dated May 11, 1988, reprinted with corrections August 1, 1989. Specific project criteria and deviations from the general specifications are given in the following sections.

Project Network - A list (Table 1) and sketch of stations involved in this project have been provided.

Data Acquisition - Data collection must be accomplished as specified in the appropriate dual-frequency receiver field manuals in the compressed mode at a 15-second epoch collection interval. The GPS receivers must be dual-frequency and full-wavelength. Track satellites down to a 10-degree elevation angle.

The satellite observing scenario has been provided in Table 2. Sessions will generally begin at two observing windows at least 4 hours apart - 1400 UTC and 1810 UTC. Vectors between the project stations shall be measured by single sessions consisting of continuously and simultaneously tracking for 5 1/2 hours.

Each FBN station must be occupied at least three times - twice at one observing window and once at the other. Each FBN station must be tied to two different bench marks. This bench mark tie requirement can be satisfied in one or two sessions. Adjacent FBN stations must be directly connected in at least one observing session, and at least one-half of all FBN base lines must be repeated. The CORS base lines will be repeated. CORS and CTCORS data will be used throughout the project.

For this project, each CBN station must also be occupied three times as described above. However, CBN stations can be tied to adjacent FBN stations (if the FBN station is closer than a CBN station), and a base line consisting of a CBN station and a FBN

station can be used in the repeated-base line requirement

mentioned above for the CBN portion of this project. The two bench mark tie requirement also applies to the CBN.

Record weather data just before, immediately after, and at the mid-point of each session. Meteorological data shall also be collected immediately after an obvious weather front passes during a session and immediately before it passes, if possible. Pressure and relative humidity measurements must be made near and at about the height of the GPS antenna phase center. Indicate in the log the location of the barometer and psychrometer.

Survey operations shall be conducted with due regard to the safety of personnel and equipment. Contact with the airport traffic control tower is mandatory during surveys at any controlled airports.

Vector Computations - Data management, quality review of collected data, and final vector processing for the FBN survey will be accomplished by the NGS project coordinators using PAGES. Vectors shall be computed in the International Earth Rotation Service Terrestrial Reference Frame (ITRF) system, using the most current epoch and precise IGS ephemerides. Use 30-second epoch intervals for data processing. Monument positions will be used for CORS when available, otherwise, antenna reference point (ARP) positions will be used. (Mr. Jeff Olsen, N/NGS4, will be responsible for Virginia, and Mr. Gary Means, N/NGS412, will be responsible for West Virginia.)

The data will be processed in 24-hour sessions (or slightly longer if the observation session crosses 0000 UTC) in order to

utilize the 24-hour data sets collected at the CORS and CTCORS.

The "fixed baseline" option in PAGES will be used to compute direct baselines between the CORS and CTCORS. The "fixed baseline" scheme will depend on the location and reliability of

the CORS and CTCORS used in this project. Contact Ms. Juliana Blackwell, N/NGS41 (see LIAISON), for specific information relating to this project.

For stations where weather data are not available, or are suspect, predicted values computed based on the station's latitude, height above mean sea level, and time and day of year will be used. Use 15 degrees as the cutoff elevation

angle in data processing. A cutoff angle of 10 degrees may be used when necessary to improve results.

The type of final solution, L1 versus ion-free, will depend on the length of the vectors. For vectors which are less than 10 km in length, the final reduction will consist of a L1 fixed solution. These vectors will be computed in a separate processing session from the longer vectors computed in an ion-free solution.

In general, vectors greater than 10 km in length are to be computed in an ion-free fixed, or partially-fixed, solution. In all cases, integer ambiguities will be fixed for each vector whenever possible.

For the four pairs of CORS reference marks, the CORS antenna at each site will be used as the reference station in the data processing.

The quality of collected data shall be determined from the plots generated from PAGES, by analysis of repeated vectors and/or comparison of station positions, and free adjustment residuals and/or loop misclosures. In addition, a constrained adjustment constraining all CORS will be performed.

The NGS project coordinators will perform all quality checks for conformance with NGS format standards such as executing software programs COMPGb, OBSCHK, and OBSDES. The final ITRF vectors will be assessed and transformed to the NAD 83 coordinate system using program ADJUST.

The data and results will be submitted to the Observation and Analysis Division. All B-files and G-files must be complete, including *25* and *27* records.

Station Descriptions - Station recovery notes must be submitted in computer-readable form using DDPROC software. Include the name, address, and, if public ownership, the telephone number of the responsible party. Do not include the telephone numbers of private property owners.

Special Requirements - Antenna set-up is critical to the success of this project. Fixed-height tripods are preferred for all receivers. The plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is performed. They must be shaded for 3 minutes before checking and/or re-plumbing. Also, the perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders from occurring. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above the mark in both metric and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

Some GPS antennas have detachable ground planes and radomes. In order to help identify what exactly was used at a particular site, it would be useful to have a snapshot of the setup. All co-observers should take a photograph of the setup, if possible, with a close-up of the antenna as viewed from the side.

In addition, a rubbing of the stamping of the mark must be made at each visit to a station. If it is impossible to make a rubbing of the mark, a plan sketch of the mark must be substituted, accurately recording all markings.

Also, for each station visited, a visibility obstruction diagram must be prepared and the TO-REACH description carefully checked for errors or omissions.

Lastly, the following must be recorded at each occupation of a station:

- (1) receiver manufacturer,
- (2) antenna manufacturer,
- (3) receiver model number (part number),
- (4) antenna model number (part number),
- (5) the complete serial number of the receiver, and
- (6) the complete serial number of the antenna.

Success of this project requires that the highest quality GPS data be collected. Therefore, during each station occupation, the operators shall carefully monitor the operation of the receivers. Any irregularities in the data due to equipment malfunction, DOD adjustment of the satellite orbit, obstructions, etc., must be reported to the Field Operations Branch, N/NGS41, as soon as possible and noted on the observing log. If the quality of observations for an observing session is questionable, notify the Field Operations Branch immediately.

The survey team shall not depart the project area until they have quality reviewed all data, advised N/NGS21, and notified N/NGS41.

GPS DATA:

Visibility tables and plots of the present satellite constellation for February 16, 2000, have been reviewed and two observing windows selected. For operational use, current data must be generated with Trimble mission planning software or from program SATMAP.

Project report and data listed in Annex L of "Input Formats and Specifications of the NGS Data Base" and in the attached addendum for the adjustment portion must be transmitted. Any data considered suspect as to quality in achieving accuracy standards should be sent via FedEx immediately for office review. Backup of transmitted data must be held until notified by the Field Operations Branch, N/NGS41.

The data sets collected during the project shall be named "varo020d.726" for Virginia and "wvro030d.750" for West Virginia. All records in connection with this project shall be titled "VIRGINIA FBN, 2000" for Virginia and "WEST VIRGINIA FBN, 2000" for West Virginia. The project numbers (accession numbers) are GPS-1188 for Virginia and GPS-1462 for West Virginia.

LIAISON:

Liaison must be maintained with designated offices at the National Geodetic Survey headquarters located at:

1315 East-West Highway
Silver Spring, Maryland 20910-3282

Questions and problems concerning survey field operations should be directed to:

William T. McLemore, Jr.
Chief, Field Operations Branch
Observation and Analysis Division
N/NGS41, SSMC III, Station 8564
Telephone: 301-713-3215, ext. 117
Fax: 301-713-4327
e-Mail: mclemore@ngs.noaa.gov

Questions and problems concerning adjustment processing should be directed to:

Maralyn L. Vorhauer
Observation and Analysis Division
N/NGS4, SSMC III, Station 8562
Telephone: 301-713-3176, ext. 104
Fax: 301-713-4327
e-Mail: maralyn@ngs.noaa.gov

Questions and problems concerning vector processing should be directed to:

Juliana Blackwell
Field Operations Branch
Observation and Analysis Division
N/NGS41, SSMC III, Station 8458
Telephone: 301-713-3215, ext. 108
Fax: 301-713-4327
e-Mail: Juliana.Blackwell@noaa.gov

Questions and problems concerning using CORS data in processing should be directed to:

Neil Weston
Geosciences Research Division

N/NGS6, SSMC III, Station 9830
Telephone: 301-713-2847, ext. 202
Fax: 301-713-4475
e-Mail: nweston@ngs.noaa.gov

Questions and problems which could affect the technical adequacy of the project should be directed to:

Stephen J. Frakes (Douglas R. Hendrickson)
Chief, Project Development Branch
Spatial Reference System Division
N/NGS21, SSMC III, Station 8853
Telephone: 301-713-3194, ext. 111 (ext. 127)
Fax: 301-713-4316
e-Mail: steve@ngs.noaa.gov (dough@ngs.noaa.gov)

For tide site information, contact:

Bruce Servary
Center for Operational Oceanographic
Products and Services
Requirements and Development Division
N/OPS1, SSMC IV, Station 6425
1305 East-West Highway
Silver Spring, Maryland 20910
Telephone: 301-713-2897, ext. 183
e-Mail: Bruce.Servary@noaa.gov

The NGS project coordinators are:

For Virginia:

Jeff Olsen
Observation and Analysis Division
N/NGS4, SSMC III, Station 8504
1315 East-West Highway
Silver Spring, Maryland 20910-3282
Telephone: 301-713-3215, ext. 120
Fax: 301-713-4327
e-Mail: jolsen@ngs.noaa.gov

For West Virginia:

Gary A. Means
Field Operations Branch
Survey Section B, N/NGS412
Observation and Analysis Division
538 Front Street
Norfolk, Virginia 23510
Telephone: 757-441-6264
Fax: 757-441-6718
e-Mail: gmeans@ngs.noaa.gov

The coordinators for the CBNs are:

For Virginia:

Mike Zmuda
Virginia Department of Transportation
1401 East Broad Street, Room 914
Richmond, VA 23219
Telephone: 804-786-2565
Fax: 804-786-1788
e-Mail: zmuda_mw@vdot.state.va.us

For West Virginia:

David Sypolt
West Virginia Association of Land Surveyors
Kingwood Plaza, Suite 419
425 East Main Street
Kingwood, WV 26537
Telephone: 304-329-2325
e-Mail: tymlofp@access.mountain.net

Names and telephone numbers of local contacts are given in the station description material.

ADDRESS:

Keep N/NGS41 informed of the party's post office, physical address, and telephone number at all times.

PUBLICITY:

See "NGS Operations Handbook," Section 1.4.1.

EXPENSES:

FBN expenses for this project will be charged to task number 8K6D2000. Expenses for the CORS FBN/CBN tie will be charged to task number 8K6D4000.

TRAVEL:

Travel and per diem are authorized in accordance with Federal Travel Regulations, Part 301-11, Per Diem Allowances. Current per diem rates were effective January 1, 2000.

ACKNOWLEDGMENT:

Please acknowledge receipt of these instructions in your Monthly Report.

cc: N/NGS - D. Zilkoski*
N/NGS - S. Misenheimer*
N/NGS1 - G. Mitchell
N/NGS11 - S. Cofer
N/NGS21 - S. Frakes
N/NGS21 - R. Anderson
N/NGS21 - D. Hendrickson*
N/NGS22 - T. Soler
N/NGS3 - E. Allen
N/NGS4 - E. Wade
N/NGS4 - M. Vorhauer
N/NGS4 - D. Hoar
N/NGS4 - J. Olsen
N/NGS41 - W. McLemore
N/NGS41 - J. Blackwell
N/NGS412 - G. Means
N/NGS5 - R. Snay
N/NGS6 - N. Weston
N/OPS1 - B. Servary

FGCS Members*

Brad Foltz, Pennsylvania Department of Transportation

David Sypolt, West Virginia Association of Land Surveyors

Mike Zmuda, Virginia Department of Transportation

* first page only

**DATA TO BE SENT TO HEADQUARTERS RELATING TO
THE ADJUSTMENT PORTION OF
FBN/CBN PROJECTS**

Free adjustment in NAD 83 (UNIX run).

Plots of the free adjustment created by running "plotres_prompt.bsh" on a UNIX server. Plots require a printer that supports postscript. The output file (long.out) contains a list of residuals which may be sorted using the following commands:

```
vi long.out
:1,$ !sort +0.47 (sorts horizontal residuals)
:1,$ !sort +0.71 (sorts vertical residuals)
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(OPTIONAL) Constrained horizontal adjustment holding NGS CORS positions and ellipsoid heights.

Final combined Blue Book file (ASCII required) with *86* records (GEOID99).

Final description file (ASCII required.)

Final G-file (ASCII required.)

OBSCHK output.*

CHKDDESC output.*

OBSDES output.*

*Any errors or warning messages must be explained.